NXDN™-Forum

Information Paper

FDMA and TDMA Narrowband Digital Systems

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Introduction:

At this time, three business and industry orientated narrowband digital systems are available. Two of them are based on 6.25kHz FDMA technology and one system is based on a 2-slot TDMA modulation scheme operating in a 12.5kHz channel bandwidth.
The debate over the merits and demerits of each system have arisen, but the following are some thoughts on the matter, and to clarify certain issues heard to date.

Initial Conclusion: Which System is Better?

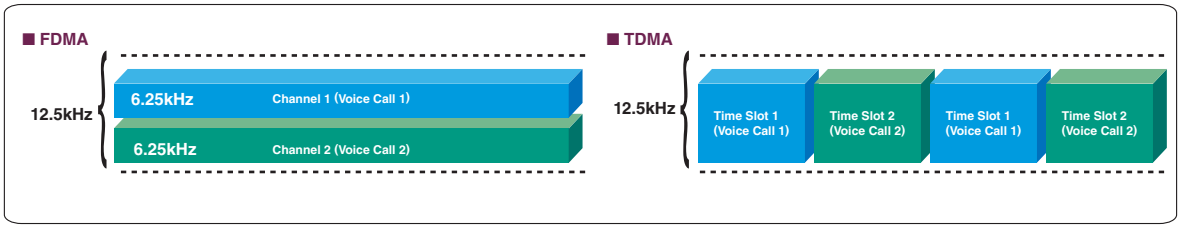
This cannot be answered as each system has its merits and demerits. We leave it up to the reader to make any necessary comparisons of each system separately based on publically available information, to make their own decision as to which system best suits their needs. Judging by current estimated numbers of FDMA and TDMA products in the market, it seems both have been widely accepted to the same degree.

Clarifying the Facts from the Fiction:

The following is an attempt to give a non-biased explanation about these 6.25kHz FDMA and 12.5kHz TDMA systems. Many of the explanations listed below are clarifications of items relating to the three systems that have appeared in the public domain to date.

The Technology:

Without getting too technical, the basic difference between FDMA (Frequency Divided Multiple Access) and TDMA (Time Divided Multiple Access) is the definition of a channel and how it is used (accessed). In FDMA a particular bandwidth (E.g. 6.25kHz) at a particular frequency (E.g. 150.000MHz) is used to define a channel. Basically, the way channels have been allocated for decades.



In TDMA, the same principle applies regarding bandwidth and frequency, but the signal is divided into time slots that allow the channel to have 'extra' capacity in the same bandwidth E.g. Two 6.25kHz 'equivalent' channels in a 12.5kHz channel. See the diagram below for a graphical explanation.

Until now, TDMA was more spectrum efficient at wider channel spacing's like 25kHz, as for example, two or three users could access the same bandwidth as one FDMA channel user. However, in the case of narrowband 6.25kHz FDMA technology like NXDN™, both this and 2-slot 12.5kHz TDMA technology achieve the same result as far as spectrum efficiency is concerned.

Proprietary or Open Protocols:

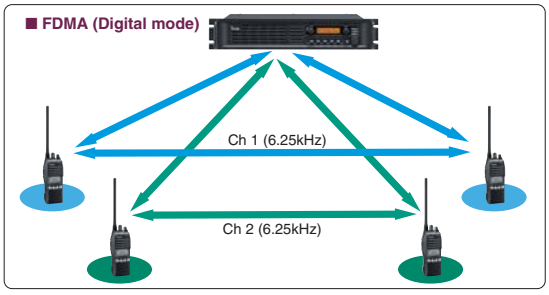
The TDMA system protocol is compliant to the open European Telecommunications Standards Institute (ETSI) technical standard TS102 361, commonly known as DMR (Digital Mobile Radio). A license and royalties to use the protocol in product development is required, but in essence, any manufacturer can develop DMR compliant products.

To date the TDMA system now has three vendors supplying both terminals and infrastructure radio systems. Radio products compliant to the NXDN™ protocol are currently offered by three manufacturers also.

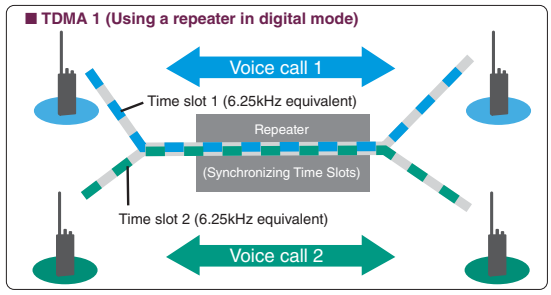
The answer as to whether either technology is open or proprietary is now actually irrelevant. The NXDN™ Forum has recently announced the opening of the NXDN™ standard, details of which can be found on the NXDN™ Forum website.

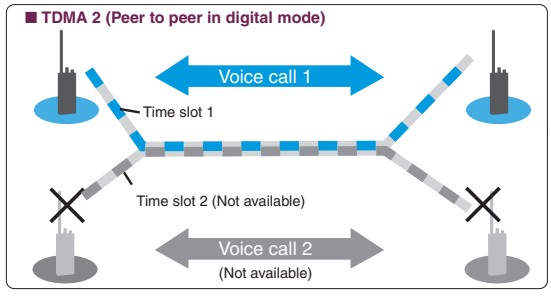
Spectrum Efficiency and "Double Capacity":

As explained above, both technologies achieve the same 6.25kHz narrowband capability via different methods. The difference is that the FDMA system is a 'true' 6.25kHz channel and the TDMA system provides 6.25kHz channel 'equivalence' via the time slots in 12.5kHz bandwidth. From the perspective that 12.5kHz is considered the current narrowband standard channel spacing, then both systems achieve so called "double capacity". The difference is that the FDMA system is ALWAYS double capacity whether it is used with or without infrastructure if you consider 12.5 kHz is the standard narrowband channel spacing. For TDMA, double capacity is ONLY achieved when a repeater is synchronizing the time slots, and that two users are in the same geographical area, accessing the same repeater at the same time. See the diagram below.



• The FDMA is always double capacity, whether in peer to peer or via a repeater.





• Voice call 1 (Time slot 1) occupies whole channel, so time slot 2 stations cannot communicate.

It is still unclear if the TDMA system will provide a solution to utilize both time-slots in peer to peer mode, but we are aware that such a solution is being considered for APCO P25, Phase 2. Therefore, it may also eventually be available in the TDMA system discussed here.

A recent new ruling from the FCC regarding licensing of “non-standard offsets” in the UHF band (for now), allow full “double capacity” (2 x 6.25 kHz channels in a 12.5 kHz channel) for the FDMA system to provide the spectrum efficiencies it was designed for.

Audio Quality:

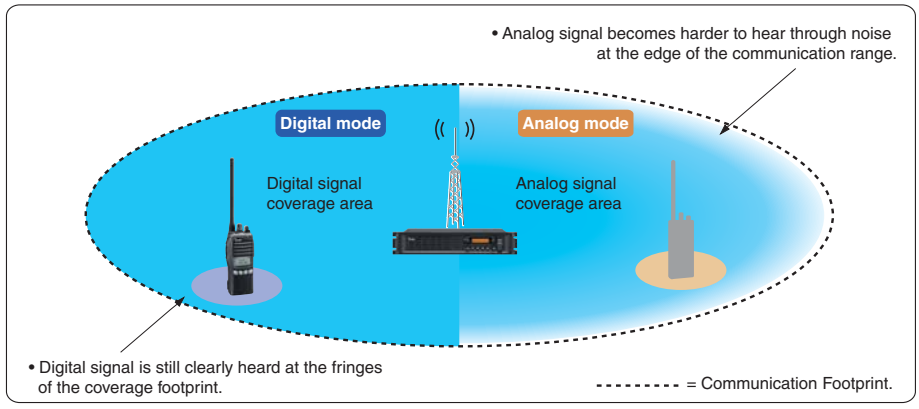
Much has been said about the improvements in audio quality of digital LMR radios compared to analog FM. Currently, both the FDMA and TDMA systems are utilizing the same vocoder, so apart from any differences in the speaker design or output; both systems' audio quality would be of a similar level.

Coverage:

In theory, in identical conditions, the narrower channel width of the FDMA system would allow the signal to achieve better coverage than the 12.5kHz TDMA (or FDMA) system when transmitted at the same output power. This is because the noise floor of any receiver is proportional to the filter bandwidth, therefore the smaller the bandwidth the smaller the signals that can be received.

In real world use, various factors such as topography, antenna height of base stations and surrounding buildings etc. all affect coverage, so without specific comparison tests, either system cannot claim to be better than the other.

What can be said is that when compared to an analog FM signal, digital easily out-performs analog at the fringes of the communication range, thus providing more reliable audio over a greater total area, even if the coverage footprint is the same as analog FM. See the diagram below for an image.



Battery Life:

Manufacturers of the TDMA system claim 40% improved battery life in digital mode as supposedly the radio is transmitting only half the time (I.e. one time slot). As explained in “Coverage”, in the FDMA system, reduced noise components with the narrower channel bandwidth improves receiver sensitivity. Therefore, it could be possible to transmit at reduced power, which in turn conserves battery life and prolong radio use time.

In the three to four years that both technologies have been in the market, there has been no clear of decisive discussion or proof that TDMA battery life is better or that FDMA battery life is inferior. Therefore, the best conclusion to make is that users are most likely satisfied with the performance of both technologies.

System Costs:

It was initially often said that the FDMA system would be potentially more expensive for licensing costs and system set up costs (As for example more repeaters are required). Such arguments assume that all equipment would be priced the same, which is obviously not the case. However, the current situation as mentioned above shows both technologies being widely accepted by the market and many licensing

administrations have moved to accommodate 6.25 kHz FDMA band plans and/or licensing. Final system costs should really be considered in totality looking at not only the equipment cost, but site costs and support and maintenance of installed systems among others.

Interference Issues:

Any issues hinted at or insinuated regarding 6.25 kHz FDMA interference at the early stages of its release are well and truly invalid now. 6.25 kHz FDMA products hold identical type approvals worldwide as their TDMA counterparts which depending on the type approval standard used, can be more difficult to comply with at the narrower channel spacing (meaning better performance). Further, frequency coordination guidelines are firmly in place so that existing systems and new narrowband systems operate with the minimal interference as they do in the analog world.

Digital Functions:

Both the FDMA and TDMA systems offer a number of functions in both analog and digital modes. A separate comparison of each system by the reader is recommended to obtain better knowledge of which system may suit your requirements, but we will list up what we see as common to both systems for digital features.

- **Dual mode capability**
  Both systems have analog and digital 'dual mode' capability, and compatibility with existing analog FM systems.
- **Peer to peer communication**
  At the moment, only the 6.25 kHz FDMA system can communicate peer to peer in digital mode. Therefore, from a spectrum efficiency point of view, FDMA still has an advantage in peer to peer communication mode.
- **Signaling and Call type features**
  Although the naming may differ between systems, the digital equivalent of individual call, group call, selective call, data calls, status messages etc. exist in both systems to one extent or another.
- **Digital trunking**
  Digital trunking systems (single, multi-site) are available from both technologies.
- **Network interfacing**
  Both systems have the capability for networking and/or IP linking for wide-area systems.

- **Applications**
  Each system has and offers third party application programs to add to and enhance the system and its features.

Interoperability:

The minimum requirement for interoperability is the following:

* More than one manufacturer offering a product utilizing a common protocol.

* All manufacturers of such a protocol being compliant with the minimum feature set.

The NXDN™ interoperability and conformance test suites exist so that any manufacturer developing a product correctly based on the respective standard can be interoperable with another manufacturer's radio. The same exists for the TDMA system in the European standards.

It should be noted that "variants" of the TDMA system exist that may not necessarily comply with the original standard. Potential users are advised to check carefully that the features they require work properly between different vendor's products if it is intended to use various brands in a system.

To End:

As shown in this paper, both FDMA and TDMA offer similar advantages and features. We hope that the information provided here has helped clarify some questions you may have had, or given you some new information to reference. It is certainly an exciting time for both manufacturers and users regarding the potential of narrowband digital LMR radio in non-public safety markets around the world, and will remain so for quite some time to come..

Please Remember:
If you are a radio user, the following applies to you!

1/1/2013 Radio systems must operate in 12.5 kHz or narrower channels

More details here:

http://transition.fcc.gov/pshs/public-safety-spectrum/narrowbanding.html

Disclaimer

The information presented here is intended to be for clarification and/or information purposes only, and care has been taken to keep the content as neutral and accurate as possible.

It is assumed that the reader of this paper knows what FDMA and TDMA digital narrowband radio systems are currently available in the Land Mobile Radio (LMR) market, and as a result, no direct reference to competing system names or manufacturer names is used here.

The NXDN™ Forum does not represent that the content of this paper is a detailed comparison of each system, or that the content should be relied upon for comparison purposes.

While care has been taken to ensure the content of this paper is correct and accurate, the NXDN™ Forum assumes no responsibility for any mistakes or inaccuracies. The NXDN™ Forum reserves the right to amend any part of this paper at any time without notice or obligation.